

STADTREGION

Office for spatial analysis
and consultancy

Assessment of the sustainability potential of brownfield sites

STADTREGION

Office for spatial analyses and consultancy

Hornemannweg 5

30167 Hannover

Tel. 0049 - 511 228 2004

Fax: 0049 - 511 228 2461

E-Mail: info@StadtRegion.net

URL: www.StadtRegion.net

Hannover, December 2010

This material is part of a project to apply the assessment tool to a brownfield site in the city of Indianapolis. The project is supported by TASK.



In 2000, the United States Environmental Protection Agency (EPA) and the German Federal Ministry of Education and Research (BMBF) continued a cooperative effort to share information and evaluate new solutions and tools for the redevelopment of contaminated sites. By using model projects to demonstrate exemplary approaches to site redevelopment, the Bilateral Working Group (<http://www.bilateral-wg.org/>) aims to evaluate new approaches and technologies and then transfer lessons learned throughout the U.S. and Germany. Since 2005, the working group is in Phase 4 with the focus of exchange on approaches, strategies, and decision tools for sustainable brownfield revitalization.

Since 2009 the activities are performed under a Cooperative Research and Development Agreement (CRADA) between the Helmholtz-Centre for Environmental Research, UFZ (<http://www.ufz.de/>) and the US EPA. Those activities are financially supported by the Terra- Aqua- and Site Remediation Centre of Competence Leipzig (TASK) (<http://www.task-leipzig.de/>). This initiative endeavours to increase and improve the visibility, acceptance and marketability of new innovative technologies and concepts in the fields of soil and groundwater, contaminated site revitalisation and remediation. National and international existing knowledge and experience should be spread and used more efficiently.

In November 2009 a workshop on “Sustainability Assessment Tools - Practical Applications in Germany and the US“, took place in Denver. Based on the results of the discussion, two German and two US-American tools were chosen to be applied each in the tools and allows actors to use it for future projects.

One of the tools applied is the SINBRA – Sustainability Assessment. Since November 2010 the Brownfield Redevelopment Coordinator of the City of Indianapolis and the German office which developed the tool have cooperated for implementing it for a brownfield site in Indianapolis.

Preliminary remarks

The following report presents the procedure for assessing the sustainability potential of brownfield sites that has been developed within the framework of the interdisciplinary project “Strategies for the revitalisation of brownfield areas (SINBRA)” funded by the German Federal Ministry of Education and Research (BMBF).

The text is an abridged version of the final project report from July 2009, which can be downloaded from www.stadtregion.net www.stadtregion.net.

Assessment of the sustainability potential of brownfield sites

The potential that brownfield sites hold for sustainable urban development varies according to the future land use that is planned for the individual sites. This assessment procedure has been developed to assess what kind of future land use will achieve the goals of sustainable urban development and which land uses will run contrary to these goals. The procedure is to be applied before any plans have been defined to develop the site.

In the following, the basic principles of the assessment procedure – the framework of general goals and sub-goals of sustainable urban development – are presented (1), the assessment matrix, generated from the site characteristics and types of land use, is explained (2.1) and the assessment method (2.2) and the results of the procedure (2.3) are described. The site characteristics (2.4) and the types of land use (2.5) are subsequently explained in detail.

1. Framework of general goals and sub-goals of sustainable urban development

The basis of the assessment procedure is formed by the goals of sustainable urban development. They represent the three dimensions of ecological, social and economic sustainability and have been derived from an analysis of German academic studies and pilot projects. The goals of sustainable urban development are structured in a “target framework” comprising general goals and the sub-goals that substantiate them.

This framework of general and sub-goals for the procedure for assessing the sustainability potential of types of land use is summarised in the following tables.

Table 1: General goals of sustainable urban development

General Goals	Brief description
Economical land management	To avoid the use of unsealed natural or semi-natural areas and safeguard natural soil functions.
Preservation of nature and the landscape	To protect the ecological functions of nature and the landscape and eliminate environmental damage.
Mobility management that saves resources and reduces emissions	To promote structures and facilities that fulfil mobility requirements but minimise emissions and the consumption of resources.
High-quality of environment for housing and living	To ensure goods and services are provided in the vicinity, to avoid negative impacts on the well-being of residents and to promote their identification with the vicinity.
Strengthening of the local economy	To ensure the local authority's economic discretion through lowering infrastructure costs, safeguarding existing workplaces and stimulating new ones.

**Table 2: Framework of general goals and sub-goals
of sustainable urban development**

General Goals	Sub-goals
Economical land management	<ul style="list-style-type: none"> ▪ To provide short distances through complementary land uses ▪ To avoid additional sealing of soil ▪ To promote development within settled areas
Preservation of nature and the landscape	<ul style="list-style-type: none"> ▪ To preserve sites that are important for the urban ecology ▪ To conserve protected areas
Mobility management that saves resources and reduces emissions	<ul style="list-style-type: none"> ▪ To avoid overburdening the local road network ▪ To reduce individual car use ▪ To protect the population against the impacts of traffic emissions ▪ To promote non-motorised mobility
High-quality of environment for housing and living	<ul style="list-style-type: none"> ▪ To provide services in the vicinity ▪ To conserve and develop leisure and recreational facilities in the vicinity ▪ To conserve and upgrade the urban landscape ▪ To minimise conflicts between types of land use
Strengthening of the local economy	<ul style="list-style-type: none"> ▪ To minimise the burden on the local authority budget from investment and follow-up costs involving network-related infrastructure ▪ To minimise the burden on the local authority budget from clean-up costs ▪ To enhance the attractiveness of the location for investment ▪ To safeguard industrial and trade locations

2. Assessment procedure

The potential that an area has for sustainable urban development depends on its features and its use. The specific features of the location and of the brownfield site and the effects that are caused by the various land uses on the site and its surrounding area are to be taken into consideration in equal measure. This assessment procedure thus combines the **characteristics of a site** with the effects of different **types of land use**.

The **site characteristics** represent the five general goals and 17 sub-goals and thus the potential of a brownfield site to achieve the different sub-goals of sustainable urban development through future land use. The majority of the sub-goals are represented by only one characteristic. Some, however, are represented by several characteristics so that their multidimensional nature can be recognised.

The multitude of possible land uses have been summarised in **types of land use**. As the assessment of the sustainability potential of the site is conducted at a time when there is still no concrete plan to develop it and the type of future land use is thus basically unlimited, types of land use have to be categorised if comparable assessment results are to be obtained. One specific type uses land in comparable ways and has similar positive or negative consequences for a site itself and the surrounding areas. On the other hand, the types of land use clearly vary in the effects they have on the goals of socially, ecologically and economically sustainable urban development.

In the following, the assessment matrix that is generated from the site characteristics and types of land use (2.1) and the assessment methods (2.2) are described; the re-

sults of the assessment procedure (2.3) are outlined; finally, the site characteristics to be assessed (2.4) and the types of land use (2.5) are defined in detail.

2.1 Matrix for the assessment of the sustainability potential of brownfield sites

The following matrix (Table 3) summarises the potential of a site for sustainable urban development in connection with its usage. The site characteristics that are relevant for the goals of sustainable urban development are given in the rows, while the columns contain the types of land use.

Each cell represents a specific combination of site characteristic and type of land use and assesses the sustainability potential of this specific combination. Here, “plus 1” means that this combination of a site characteristic and a type of land use will have a positive effect for sustainable urban development, “minus 1” that negative consequences can be anticipated from this combination of site characteristic and type of land use. A “0” indicates that neither positive nor negative effects for sustainable urban development can be expected from the future application of that particular type of land use on a site with those specific characteristics or that the effects cannot be clearly determined in advance.

The experts making the assessment decide in the assessment procedure whether the respective site characteristic is present. The answers “yes” or “no” lead to the “automatic” implementation of assessments of the respective sustainability potential, i.e. for a location with this particular characteristic each type of land use is assigned a positive, a negative or a neutral effect for the goals of sustainable urban development.

Table 3: Site characteristics and types of land use for the assessment of sustainability potential

			Types of land use						
Site characteristic	Weighting coefficient	Specification	I. Residential	II. Local Services	III. Public green	IV. Small enterprises, service industries	V. Emission-generating industries, logistics	VI. Large-scale business centers	VII. Mono-functional facilities with large open space
Filter: Site smaller than 5 acres			suitable					not suitable	
1. General goal: Economical land management									
Sub-goal 1.1: To provide short distances through complementary land uses									
1.1.1 Residential population in the surrounding area	10	yes	0	+1	+1	+1	0	0	0
		no	0	-1	0	0	0	0	0
1.1.2 Public green within walking distance	10	yes	+ 1	0	0	0	0	0	0
		no	0	0	0	0	0	0	0
1.1.3 Small-scale businesses and services within walking distance	10	yes	+1	0	0	0	0	0	0
		no	0	0	0	0	0	0	0
1.1.4 Adjacent land uses with heavy emissions	20	yes	-1	0	-1	0	0	0	-1
		no	0	0	0	0	0	0	0
Sub-goal 1.2: To avoid additional sealing of soil									
1.2 Site shows minor sealing (<40%)	10	yes	0	0	+1	-1	-1	-1	+1
		no	0	0	-1	0	0	0	-1
Sub-goal 1.3: To promote development within settled areas									
1.3 Location within the settlement area	40	yes	+1	+1	0	+1	0	0	0
		no	-1	-1	0	-1	0	0	0
2. General goal: Preservation of nature and the landscape									
Sub-goal 2.1: To preserve sites that are important for the urban ecology									
2.1.1 Part of the local habitat network	40	yes	-1	-1	0	-1	-1	-1	-1
		no	0	0	0	0	0	0	0
2.1.2 High-value tree or plant populations	20	yes	0	0	0	0	-1	-1	0
		no	0	0	0	0	0	0	0
Sub-goal 2.2: To conserve protected areas									
2.2 Directly adjacent to protected area	40	yes	-1	0	0	0	-1	-1	0
		no	0	0	0	0	0	0	0
3. General goal: Mobility management that saves resources and reduces emissions									
Sub-goal 3.1: To avoid overburdening of the local road network									
3.1 Little capacity of access roads	30	yes	0	0	0	-1	-1	-1	-1
		no	0	0	0	0	0	0	0
Sub-goal 3.2: To reduce individual car use									
3.2 Good public transport	40	yes	+1	+1	+1	+1	0	+1	+1
		no	-1	-1	0	-1	0	-1	-1
Sub-goal 3.3: To protect the population against the impacts of traffic emissions									
3.3 Easy access to freeways	20	yes	0	0	0	0	+ 1	+1	0
		no	0	0	0	0	-1	-1	0
Sub-goal 3.4: To promote non-motorised mobility									
3.4 Good accessibility for cyclists	10	yes	+1	+1	+1	+1	+1	+1	+1
		no	-1	-1	-1	-1	0	0	0

			Types of land use							
Site characteristic	Weighting coefficient	Specification	I. Residential	II. Local services	III. Public green	IV. Small enterprises, service industries	V. Emission-generating industries, logistics	VI. Large-scale business centers	VII. Mono-functional facilities with large open space	
4. General goal: High quality environment for housing and living										
Sub-goal 4.1: To facilitate the provision of services in the vicinity										
4.1.1 Shops and services within walking distance	10	yes	+1	0	0	+1	0	0	0	
		no	-1	0	0	0	0	0	0	
4.1.2 Primary school within walking distance	10	yes	+1	0	0	0	0	0	0	
		no	-1	0	0	0	0	0	0	
Sub-goal 4.2: To conserve and develop space for leisure and recreational facilities in the vicinity										
4.2 Importance for play, leisure, recreation	20	yes	-1	-1	0	-1	-1	-1	-1	
		no	0	0	0	0	0	0	0	
Sub-goal 4.3: To conserve and upgrade the urban landscape										
4.3.1 Building fabric defining the urban landscape	10	yes	+ 1	0	-1	+1	-1	-1	+1	
		no	0	0	0	0	0	0	0	
4.3.2 Great importance for urban landscape	10	yes	0	0	+1	0	-1	-1	0	
		no	0	0	0	0	0	0	0	
Sub-goal 4.4: To minimise conflicts between types of land use										
4.4 Adjacent usage sensitive to emissions	40	yes	0	0	0	0	-1	-1	0	
		no	0	0	0	0	0	0	0	
5. General goal: Strengthening of the local economy										
Sub-goal 5.1: To minimise the burden on the local authority budget from investment and follow-up costs involving network-related infrastructure										
5.1 Efficient public utilities infrastructure	20	yes	+1	+1	0	+1	+1	+1	+1	
		no	-1	-1	0	-1	-1	-1	-1	
Sub-goal 5.2: To minimise the burden on the local authority budget from clean-up costs										
5.2 Site extensively polluted	30	yes	-1	-1	-1	0	0	0	-1	
		no	0	0	0	0	0	0	0	
Sub-goal 5.3: To enhance the attractiveness of the location for investment										
5.3 Site suitable for innovative businesses	30	yes	0	0	0	+1	0	0	0	
		no	0	0	0	0	0	0	0	
Sub-goal 5.4: To safeguard industrial and trade locations										
5.4 Industrial and trade use with unstable location security in the immediate vicinity	20	yes	-1	0	0	0	0	0	0	
		no	0	0	0	0	0	0	0	

2.2 Methodical rules

The target situation is assessed. Using the characteristics of the site the effects of establishing a specific land use on the site itself as well as the reciprocal effects on the land use of the surrounding area are described.

The assessment procedure aims to identify the potential of reuse of brownfield sites for sustainable urban development. It assumes that reuse requires construction. Thus, the assessment procedure should be applied only where no compelling obstacles prevent buildings on the site. Indicators that rule out land use for buildings, e.g. provisions of environmental law, pollution that cannot be remediated or topographical conditions, are therefore not incorporated into the assessment.

The characteristics relate predominantly to small scale conditions, such as transport connections, adjacent land uses, soil contamination or distance from services. In order to obtain valid results for the assessment of the site potential, the procedure is therefore only to be applied for sites with to some degree homogeneous characteristics. Very large sites do not lend themselves to a clear assessment using these criteria; for example, on a large site, public transport can be 100 yards or a mile away, the soil can be heavily contaminated or hardly contaminated, the degree of sealing can be high or low and the neighbouring usage can be sensitive to pollution to a high degree or hardly at all, depending on the specific location. Very large brownfields therefore generally have to be broken down into sub-sites that exhibit similar specific characteristics. As there are no generally applicable criteria, but rather the specific combination of characteristics is to be drawn on, the local experts decide on the subdivision of large brownfields. The assessment procedure would then possibly have to be carried out in several stages, because the (supposed) allocation of a specific type of land use to a sub-site changes the starting conditions of the other sub-sites.

One requirement is that site characteristics discriminate between various land uses, i.e. different effects on the site can be expected from different types of land use. If, for example, a specific site serves as a corridor for fresh air but construction on the site is not ruled out in principle, assessing defects of different types of use will not suffice; only concrete construction plans, such as the form and the height of the building, will allow to determine its positive or negative effects on the transport of fresh air. The characteristic "function as a fresh air corridor" is thus not suitable for the assessment procedure.

The assessments are based to a lesser extent on quantitative indicators and to a greater extent on subjective evaluations. This allows for greater flexibility of the assessment and for the procedure to be applied in a variety of different cases; it ensures that the experts have a certain leeway in their assessment and makes it possible to pay attention to the conditions of a single case. If the quality of the local public transport connections of a site were measured by headways for example, this would not take into account whether it was relatively well or comparably poorly connected. In contrast, a qualitative assessment allows the relationship to the supply situation normal in the district to be produced.

In order nevertheless to ensure that the evaluators follow uniform criteria, the indicators and the assessment rules are described in detail below. The risk that personal value systems dominate the results is therefore minimised. In addition, the assessment classifications are relatively rough; this, too, increases the probability that different evaluators will come to similar results.

The assessment is based on a points system. As the use of a site may promote but also contradict the goals of sustainable urban development, both positive and negative effects are possible. Therefore, the assessment system allots:

- plus values for positive effects on the goals of sustainable urban development
- minus values for negative effects on the goals of sustainable urban development
- zero value for no effects on the goals of sustainable urban development, effects that cancel each other out or effects that cannot be determined.

Not all characteristics and indicators can make full use of the assessment range. Depending on the nature of the site, for some only positive options (e.g. development of shops and services in the neighborhood) can be selected, while only negative options (adverse impact on protected areas, emissions from motorised traffic) are available for others.

Overall, there are more possibilities for negative than for positive scores. A neutral effect, in the sense of “no adverse impact on the situation”, in most cases has to be interpreted as positive in terms of sustainable urban development. This result can be followed intuitively: construction causes adverse impacts on the site and its surrounding areas rather than an enhancement of the ecological, social and urban economic situation. It is not the establishment in the municipality itself that is assessed, but its establishment on a concrete site. As a result, possible positive aspects, such as the expansion of the housing or cultural offer in a city, the creation or safeguarding of educational and work places or the increase in business tax receipts, are not considered at all - the assessment is focused on whether the establishment of specific land uses is consistent with the goals of sustainable urban development.

The possibilities of triggering positive effects for sustainable urban development vary greatly for the types of land use. The establishment of a residential land use can, for example, stabilise mixed land use and lead to the better utilisation of capacity at nearby primary schools. On the other hand, emission-generating trade and industrial land uses exhibit few characteristics that would lead to their establishment being assessed as promoting sustainable urban development; their spectrum of negative consequences is clearly greater than that of residential land uses.

The sub-goals and site characteristics are weighted differently. The specific weights reflect that individual sub-goals contribute differently to sustainable urban development. For the overall assessment, the five general goals are each weighted equally at 20%. Detailed reasons for the specific weighting of the different sub-goals are given (cf. chapter 2.2).

The weights of the general goals and sub-goals as well as specific indicators are not binding. Distinctive local features and conditions can only be addressed imperfectly in a general assessment system. For example, cycle traffic does not offer as good an alternative to motorised traffic in mountainous regions as it does in flat regions; or, in a city with a rich architectural heritage the preservation of individual buildings may be seen as less urgent than in cities that have few identifying landmarks. To take into account different conditions and priorities in the municipalities the weighting can be adapted within certain parameters. However, amended weighting coefficients must also take into account all five dimensions of sustainable urban development and all sub-goals allocated to them; none of the general goals and none of the sub-goals may therefore be dispensed with, and the individual weighting coefficients may not fall below a minimum threshold. In any event, deviations from the suggested weighting specifications must be substantiated, so that the procedure and the result remain transparent and reproducible.

The flexibility of the assessment system also applies for the values of individual indicators (e.g. sealing degree or distance from public transport). When local conditions require other values and margins can be applied. Technical reasons should be provided for these amendments.

2.3 Results of the assessment procedure

For each type of land use, the result of the assessment is generated as a points score that is the total of the weighted assessments of the individual cells. This value characterises what effect on sustainable urban development can be expected when a site is reused according to a particular type of land use. As the individual types of land use have different maximum and mean values, the points cannot be interpreted and compared with each other directly in some form of sustainability index. In order to enable this comparison between types of land use, the resulting scores are stan-

standardised; for this, an “achievement level” is calculated which is the proportion of the points scored relative to the highest possible score.

The achievement level A is calculated as

$$A = \left(\frac{\sum P+}{P+ \max} \times 100 \right) - \left(\frac{\sum P-}{P- \max} \times 100 \right)$$

P+	= plus points (weighted)
P+max	= highest possible plus points (weighted)
P-	= minus points (weighted)
P-max	= highest possible minus points (weighted)

The achievement level expresses to what extent a specific land use at the location produces possible positive or negative effects for sustainable urban development. The achievement level thus allows a relative ranking order of the types of land use to be created: the higher the ranking, the greater the contribution that the use at this location makes to the goals of sustainable urban development. The achievement level, however, does not permit an absolute ranking scale of the various types of land use, i.e. it does not provide a statement on how much more sustainable a particular type of land use is than another.

2.4 Site characteristics for the assessment of sustainability

The five general goals and 17 sub-goals are represented by 23 site characteristics. They describe features of the site that contribute in different ways, in conjunction with future uses, to the goals of sustainable urban development.

Some land uses necessarily require that the site is of a minimum size. The size of the site is therefore introduced as a filter characteristic: for sites that are smaller than 5 acres, the effect of the type of land use “Large-scale business centers” is not assessed.

General goal 1: Economical land management

The importance of sites in terms of economical land management varies according to how they are integrated in the development and land use structure of a city (location, neighbouring land uses, structure of settlement, infrastructure, etc.). And this potential is realised by individual types of land use in different ways.

Sub-goal 1.1: To provide short distances through complementary land uses

A city of short distances has to have a variety of land uses in close proximity to each other. However, a distinction has to be drawn between land uses that are complementary and land uses that are mutually disruptive. Mixed land uses that achieve the goals of economical land management and land uses that run contrary to them are determined by means of the following four site characteristics.

Characteristic 1.1.1: Residential population in the surrounding area

Spatial reference: Close vicinity

Specification:

Large residential areas within walking distance

If land uses that provide services, recreational facilities or offer work places suitable for mixed land use are established in the vicinity of large residential areas this creates the possibility of short distances between home and services, work or recreation. If, on the other hand, public or private local providers are established some distance away

from residential areas, this produces the need for mobility. Residential areas with at least 500 residents are to be regarded as “large” and distances of less than 550 yards are to be regarded as “within walking distance”.

Characteristic 1.1.2 Public green within walking distance

Spatial reference: Close vicinity

Specification:

Open public green within walking distance for different kinds of recreation

If open spaces are available in the vicinity, the establishment of residential land uses opens up the opportunity to exercise leisure activities in the residential environment. “Within walking distance” means distances of up to 550 yards.

Characteristic 1.1.3: Small-scale businesses and services in the close vicinity

Spatial reference: Close vicinity

Specification:

Small-scale businesses and services within walking distance

If small-scale businesses and service providers are located in the surrounding area, the establishment of residences creates the possibility of short journeys between home and work. “Within walking distance” means distances of up to a maximum of 550 yards.

Characteristic 1.1.4: Emissions of adjacent land uses

Spatial reference: Close vicinity

Specification:

Adjacent land use produces heavy emissions (noise, traffic)

Proximity of different land uses support the goals of economical land management only if these uses are compatible with each other. The potential of a brownfield site for future use is severely limited when it is located next to uses with heavy emissions. Conversely; if the site is not suited for land uses that are sensitive to disturbances, such a use would have an adverse impact on the location security of resident emitters.

Sub-goal 1.2 To avoid additional sealing of soil

Characteristic 1.2: Degree of sealing of the site

Spatial reference: Project site

Specification:

Site with minor sealing (less than 40%)

Different land uses require different soil sealing. Additional sealing on brownfield sites with minor sealing can be avoided if types of land use are excluded that require a high degree of sealing. On the other hand, if these kinds of land use are established on highly sealed brownfield sites, hardly any additional sealing will be required.

Sub-goal 1.3 To promote development within settled areas

Characteristic 1.3: Location within the settlement area

Spatial reference: Residential area in the municipality

Specification:

Location within the settlement area

Types of land use that are compatible with mixed land use, such as housing, small-sized facilities and services, should be located within the settlement area; their establishment in the outskirts runs contrary to the goals of compact settlement, short distances and reduction of land use. For highly disruptive, very traffic-intensive or leisure-oriented land uses the effects are different, because their establishment could have adverse social and ecological impacts. If they are established in the outskirts, this does not contradict the goals of sustainable urban development in principle.

Weights of the sub-goals

The three sub-goals make different contributions to the general goal of “economical land management” and are therefore weighted differently.

No.	Sub-goal	Weighting
1.1	To provide short distances through complementary land uses	50%
1.2	To avoid additional sealing of soil	10%
1.3	To promote development within settled areas	40%

All three sub-goals aim to use land and soil sparingly, as stipulated in section 1a (2) *Baugesetzbuch* (BauGB – German Federal Building Code). Of central importance for this is the reduction of land use, which is supported primarily by the promotion of the development within settled areas (sub-goal 1.3). This sub-goal is therefore given a high weight with 40%.

Mixed land uses support spatial concentration, short distances (sub-goal 1.1), and reduction of consumption of land; its role for economical land management is thus given, at 50%, an even higher weight as the promotion of development within settled areas. Of the four characteristics of this sub-goal only “Adjacent land uses with high emissions” aims to avoid conflicts arising from mixed land use; it is therefore given a higher weighting (20%) than the other three (each at 10%).

The avoidance of additional sealing of soil (sub-goal 1.2) aims to protect ecological soil functions; it has thus only a supplementary character in terms of measures for economical land management and is therefore given the lowest weighting at 10%.

General goal 2: Preservation of nature and the landscape

Sites are differentiated according to their importance for nature and the landscape, land uses are differentiated according to the pressure they place on the ecological values of sites. In order to safeguard ecologically important sites for sustainable urban development, the types of land use they are burdened with and to what extent have to be assessed.

Sub-goal 2.1 Preservation of land that is important for the urban ecology

Spatial reference: Project site

Specification:

Site is part of a municipal habitat network or holds great importance for the urban ecology

Sites that form part of a municipal habitat network hold great importance for the urban ecology. In municipalities where there are no habitat networks, a decision has to be made on whether the site has an important function in terms of the urban ecology (e.g. for the urban climate, as a fresh air corridor, for the green network, etc.). Every type of construction on the site puts this function at risk and is therefore to be assessed in negative terms.

Characteristic 2.1.2: High-value tree or plant populations in dispersed state

Spatial reference: Project site

Specification:

High-value tree and/or plant populations are dispersed across the site

High-value tree populations or habitats are to be given particularly strong protection when they are not spatially concentrated but scattered over the site. Types of land use are differentiated according to whether their structural layout can be adapted to a given distribution of high-value flora. Types of land use with small-scale building and development structures open up the possibility of avoiding the destruction of tree and plant populations and minimising their burden.

Sub-goal 2.2 Preservation of protected areas

Characteristic 2.2: Adjacent protected areas

Spatial reference: Project site and directly adjacent sites

Specification:

Site is located directly adjacent to a protected area

Every land use that borders a protected area impairs the latter's protective function. The extent of the impairment differs according to the individual type of land use: the heavier the activities originating from a land use, the greater its risk potential.

Weights of the sub-goals

Both sub-goals have great importance for the general goal of "preservation of nature and the landscape". The sub-goal "preservation of land that is important for the urban ecology" is given greater weighting at 60%, however, because the two characteristics "part of the municipal habitat network" and "high-value tree or plant populations" present more heterogeneous circumstances for the achievement of the goal.

No.	Sub-goal	Weighting
2.1	To preserve sites that are important for the urban ecology	60%
2.2	To conserve protected areas	40%

General goal 3: Mobility management that saves resources and reduces emissions

The important role that a site can play in promoting mobility management that saves resources and reduces emissions depends on its location and its connection to the transport network. These criteria help to assess which type of land use with its respective incidence of traffic and traffic emissions is compatible with the demands of the city and which is not.

Sub-goal 3.1 To avoid overburdening the local road network

Characteristic 3.1: Integration in the intra-municipal road network

Spatial reference: Close vicinity

Specification:

Access roads of the local road network only have minimal reserves to absorb an increased incidence of motorised traffic

If the road network in the close vicinity of the brownfield site only has a low capacity to absorb the traffic volume caused by future land use, this can lead to disruptions to the traffic flow through the creation of traffic congestion and a shortage of parking places. The consequence of these disruptions is a higher consumption of resources and

higher emissions. Types of land use that involve high-volume traffic can produce these problems in particular.

Sub-goal 3.2 To reduce individual car use

Characteristic 3.2: Connection to the local public transport network

Spatial reference: Project site and close vicinity

Specification:

Good and efficient connection to the local public transport network (stop or station a maximum of 300 yards away; headway, capacity and connections correspond to the level customary in the district)

For all land uses with a high incidence of the general public, an efficient connection of the site to the local public transport network increases the chances of reducing individual car use. The opposite is also true: an inefficient connection to the local public transport network for these types of land use increases the incidence of motorised traffic. "Efficient" refers in particular to the capacity and frequency of services offered by the local public transport network.

Sub-goal 3.3 To protect the population against the impacts of traffic emissions

Characteristic 3.3: Easy access to freeways

Spatial reference: Municipal road network

Specification:

Highway access can be reached in less than 5 minutes

A good connection to the highway network is an important requirement for land uses with a high supra-regional incidence of transport or high supra-regional visitor traffic. When there is a lack of connections, it can be anticipated that the population will suffer from increased emissions.

Sub-goal 3.4 To promote non-motorised mobility

Characteristic 3.4: Infrastructure for cyclists

Spatial reference: Project site and close vicinity

Specification:

Good accessibility for cyclists

The bicycle-friendly infrastructure of a location offers the incentive to use the bicycle as an alternative to motorised traffic. The following should be taken into consideration as characteristics of bicycle friendliness in the assessment: integration in the cycle lane network or short distance to the cycle lane network, quality and utilisation of the lanes, accessibility and easy crossing of surrounding transport infrastructure.

Weights of the sub-goals

The four sub-goals of the general goal of "mobility management that saves resources and reduces emissions" differ in their focus. Two sub-goals aim at reducing the proportion of individual car use and two aim at reducing emissions from and the consumption of resources by motorised traffic, primarily goods traffic. These two aspects are of equal value.

For the reduction of individual car use, good public transport (sub-goal 3.2) is more effective and thus is given a higher weighting at 40% than the promotion of non-motorised mobility (10%).

For the reduction of emissions and consumption of resources, the avoidance of additional pressures on the local road network has a greater significance and is therefore

given a higher weighting at 30% than a close spatial allocation of high-volume traffic uses and efficient highways (20%).

No.	Sub-goal	Weighting
3.1	To avoid overburdening the local road network	30%
3.2	To reduce individual car use	40%
3.3	To protect the population against the impacts of traffic emissions	20%
3.4	To promote non-motorised mobility	10%

General goal 4: High quality environment for housing and living

The potential of a site to contribute to a high quality of living conditions and a high quality of life depends heavily on the land uses that surround it. On the one hand, the land uses in the vicinity determine whether a brownfield site is suitable for residential purposes. On the other, different effects on the quality of living conditions and quality of life in the neighborhood are created depending on the type of future land use of the brownfield site.

Sub-goal 4.1 To facilitate the provision of services in the vicinity

Characteristic 4.1.1: Shops and services in the close vicinity

Spatial reference: Close vicinity

Specification:

Shops and services within walking distance

A brownfield site located close to where goods and services are provided has a high quality for residents and workers. And vice versa, lack of shops and services in the vicinity reduces the quality of a site as a residential location. "Within walking distance" means distances of up to a maximum of 550 yards.

Characteristic 4.1.2: Schools in the close vicinity

Spatial reference: Close vicinity

Specification:

Primary school within walking distance

When a primary school is located in the close vicinity of the brownfield site, it is particularly well suited for residential land uses, because a basic service for families with children is provided close to home. A lack of provision in the primary school area downgrades the suitability for residential land uses. "Within walking distance" means distances of up to a maximum of 550 yards.

Sub-goal 4.2 To conserve and develop leisure and recreational facilities in the vicinity

Characteristic 4.2: Importance as a play, leisure and recreational area

Spatial reference: Project site

Specification:

The site has a great importance for play, leisure and recreational activities for the close vicinity

When a brownfield site has acquired a great importance for the leisure and recreational activities of the residents in the vicinity through intermediate land uses, any conversion reduces their quality of living conditions and quality of life. The estimation of the importance as a play, leisure or recreational area depends on its accessibility and

intensity of use as well as on whether alternative facilities are located in the close vicinity.

Sub-goal 4.3 To conserve and upgrade the urban landscape

Characteristic 4.3.1: Building fabric with a character that defines the urban landscape

Spatial reference: Project site

Specification:

Building fabric with a character that defines the urban landscape on the site

Edifices of cultural significance or historical importance for the city contribute to the quality of living conditions and quality of life in a municipality. The possibility of conserving this kind of building fabric that defines the urban landscape when reusing sites varies according to the type of land use. Small-sized business and services may be able to adapt relatively flexibly to existing structures and frequently enjoy the promise of an improved image from reuse. The space and use requirements of larger production plants or shopping centres are, on the contrary, to a large extent predetermined by their function and therefore unable to adapt to given conditions.

Characteristic 4.3.2: Important for the urban landscape

Spatial reference: Project site

Specification:

Site defines the urban landscape

Thanks to their particular topography and location or their proximity to architecturally important buildings, representative public facilities or public squares, individual sites can exert a special degree of influence on the urban landscape. The possibilities of recognising and conserving this quality of urban development, which plays a role in the identification of residents with their city, depend on the type of future land use. While public parks, gardens and squares can support the potential of the topographical location, the requirements larger production plants or shopping centres have on a site are determined by their function, such that they are generally unable to adapt to the environment.

Sub-goal 4.4 To minimise conflicts between types of land use

Characteristic 4.4: Sensitivity of adjacent land uses to immissions

Spatial reference: Close vicinity

Specification:

Adjacent land use is sensitive to immissions

If land uses established in the area surrounding a brownfield site are particularly sensitive to immissions, this will limit the range of suitable future land uses. Functions that can be regarded as sensitive to immissions include residential, leisure and recreational functions as well as facilities such as e. g. schools and day-care centres.

Weights of the sub-goals

The general goal of “high quality environment for housing and living” is made up of four sub-goals, each with a different focus. The most important prerequisite for a high-value living environment is the prevention of serious conflicts between types of land use; sub-goal 4.4 is therefore allocated the highest weighting at 40%. The three other sub-goals are given equal value and are each weighted at 20%.

No.	Sub-goal	Weighting
4.1	To facilitate the provision of services in the vicinity	20%
4.2	To conserve and develop leisure and recreational facilities in the vicinity	20%
4.3	To conserve and upgrade the urban landscape	20%
4.4	To minimise conflicts between types of land use	40%

General goal 5: Strengthening of the local economy

Financial sustainability and economic growth in the municipality can be supported when land uses are developed on a brownfield site that keep infrastructure and clean-up costs to a minimum, safeguard existing businesses and workplaces, promote start-ups and increase the location's attractiveness.

Sub-goal 5.1 To minimise the burden on the local authority budget from investment and follow-up costs involving network-related infrastructure

Characteristic 5.1: Connection to technical network infrastructure

Spatial reference: Project site

Specification:

Efficient, high-capacity connections to the public utilities infrastructure are present on the site

Brownfields with efficient connections to the public utilities infrastructure reduce the burden on the municipal budget for subsequent land uses. Savings are only realised, however, when the future land uses are dependent on this provision of technical infrastructure; this would not be the case when the site is used as an open space, for example. If, on the other hand, there is no or insufficient network-related infrastructure present, the municipal budget will generally feel the effects when land uses are established either from investment or follow-up costs or, if an investor assumes the construction costs, from additional long-term operating costs.

Sub-goal 5.2 To minimise the burden on the local authority budget from clean-up costs

Characteristic 5.2: Site extensively polluted

Spatial reference: Project site

Specification:

Site with significant contamination of soil and water

Land uses are sensitive to polluted soil and bodies of water to different degrees. If a brownfield is contaminated, the clean-up expense for future land uses will depend on the type of land use. Industrial reuse, for example, would keep the direct and indirect clean-up costs that are incurred by the local authority lower than reuse for residential purposes.

Sub-goal 5.3 To enhance the attractiveness of the location for investment

Characteristic 5.3: Suitability of the site for innovative businesses

Spatial reference: Project site

Specification:

Building fabric and location attractive for modern, innovative enterprises

A brownfield site can be an especially attractive location for start-up and innovative enterprises as a result of its location and neighbouring land uses (e.g. as a result of its proximity to universities and research institutes or to districts with an urban milieu) or through the quality of its building fabric; it thus has the potential to develop into a nucleus for economic growth. When these sites are occupied by other land uses, this potential can not be realised.

Sub-goal 5.4 To safeguard industrial and trade locations

Characteristic 5.4: Location security of neighbouring trade and industry

Spatial reference: Close vicinity

Specification:

Adjacent trade and industrial land uses with unstable location security

If trade and industrial operations are located in the vicinity of a brownfield site, the establishment of higher ranked land uses can lead to conflicts. Future land uses of the brownfield site can have an adverse impact on the location security of the adjacent business and thus put the economic stability and security of workplaces at risk.

Weights of the sub-goals

The four sub-goals contribute to the “Strengthening of the local economy” to different degrees. The largest contribution is made by the support of innovative economic activities; the enhancement of the attractiveness of the location for investment (sub-goal 5.3) is therefore weighted at 40%. The location security of existing trade and industry as well as the avoidance of pressure on the local authority budget, on the other hand, have more of a reactive or conservative character and thus a lower weighting (20% each).

No.	Sub-goal	Weighting
5.1	To minimise the burden on the local authority budget from investment and follow-up costs involving network-related infrastructure	20%
5.2	To minimise the burden on the local authority budget from clean-up costs	20%
5.3	To enhance the attractiveness of the location for investment	40%
5.4	To safeguard industrial and trade locations	20%

2.5 Types of land use

Seven types of land use form the basis of the assessment of the location potential (Table 4). Types of land use place similar requirements on the location and site and have similar effects on the site itself as well as on the surrounding area. The types clearly vary in the effects they have on the goals of socially, ecologically and economically sustainable urban development.

In accordance with the goal of the procedure, the focus is on land uses that are connected with and require construction. However, open space with no construction has been included as an additional type. Should the assessment find that this type best fulfils the goals of sustainable urban development or has the least detrimental effects

on them, any type of land use that need buildings on the site are to be fundamentally reconsidered.

The types of land use are described below according to what effects they have on the site and their surrounding area and what relation they have to the goals of sustainable urban development.

Table 4: Types of land use

Type	Characterisation
I. Residential	<ul style="list-style-type: none"> ▪ all forms of residential buildings ▪ all green and open spaces directly connected to the residential buildings
II. Local services and residential infrastructure	<ul style="list-style-type: none"> ▪ retail shops, shop crafts and household services ▪ social and health services ▪ day care centres, primary schools
III. Public green, sports fields and playgrounds	<ul style="list-style-type: none"> ▪ Public open areas with a catchment area larger than the neighborhood. These include: ▪ public parks and gardens ▪ outdoor areas for playing sport ▪ local and town squares, fairgrounds
IV. Small-sized businesses and services	<ul style="list-style-type: none"> ▪ Private and public sector land uses where the public, functions and spatial orientation extend beyond the neighborhood. These include: ▪ trade and services, craft businesses and small-scale production plants ▪ indoor cultural, social and sports facilities ▪ administrations ▪ restaurants and hotels
V. Emission-generating production plants and transport-intensive businesses	<ul style="list-style-type: none"> ▪ large production operations ▪ production operations or facilities with heavy odour or pollutant nuisance for the close vicinity ▪ logistics companies, warehousing and whole-sale trade
VI. Large-scale business centers of regional or national importance	<ul style="list-style-type: none"> ▪ large-scale retail outlets ▪ indoor theme parks, water parks and large health and fitness centres ▪ large indoor sports facilities, event and exhibition venues ▪ large administration centres
VII. Complex mono-functional facilities with large open areas	<ul style="list-style-type: none"> ▪ large public or private facilities for education and research (e.g. campus universities) ▪ large public or private facilities for health and clean-up (e.g. clinics with car parks) ▪ other large facilities with large open areas (e.g. hotel complexes with sports facilities)

Type I: Residential

Residential land use requires a proximity to shops and services if forced mobility and accompanying individual car is to be avoided or living conditions or quality of life of less mobile sections of the population are to be improved. Residential land use is in

addition highly compatible with smaller businesses and services and is thus suitable for mixed land use.

Residential land use accommodates the sustainability goals of short distances to supply facilities and other supplementary land uses as well as the avoidance of individual car use when it is located in a developed area, is connected to the local public transport network and can be easily accessed by bicycle.

Residential land use is sensitive to contamination and noise, odour and traffic emissions. Direct proximity to land uses that generate these kinds of emissions therefore impair the quality of living conditions and quality of life.

Residential land use generates only minor adverse impacts on neighbouring land uses. An exception are protected areas, because they can suffer adverse effects from play and recreational activities of residents. Another exception is trade and industry when it sees itself put at risk by the encroachment of residential developments on its location security.

Residential land use is suitable for the reuse of architecturally important buildings that define the urban landscape because of the variety of residential requirements and building types.

Type II: Local services and residential infrastructure

This type of land use encompasses all types of use that supply the residential population in the surrounding area with goods and services ("residential downstream facilities")

Local services realise the sustainability potential of locations when residential areas are sited in their immediate vicinity. The spatial proximity of shops and services and residences enables short distances; a location within the settlement area with a connection to the local public transport network and good accessibility by bicycle avoids individual car use. In contrast, the establishment of shops and services in locations which do not exhibit these characteristics leads to increased mobility and an increased incidence of individual car use.

Thanks to their complementary function for residential land use and small businesses, shops and services and residential infrastructure facilities are suitable for mixed land use to a high degree; in addition, they generally do not react very sensitively to emission-generating operations in the surrounding area.

Type III: Public green, sports fields and playgrounds

This type of land use encompasses public open areas that are subject to intensive land use and the catchment area of which is wider than the district. Depending on their actual purpose and their size, they can have an effect in terms of sustainable development both in the settled urban area and in the outskirts.

The goals of sustainable urban development are supported to a particular degree, however, by the proximity to residential land uses, because public green, sports fields and playgrounds enhance the quality of life and shorten access to recreational areas. Connection to the local public transport network is a great advantage, accessibility by bicycle indispensable, so that children and youths can also make use of the facilities.

Outdoor land uses are sensitive to contaminated land. The same applies with regard to noise, odour and traffic emissions; therefore they are not suited for sites where the surrounding area is characterised by these kinds of pollution.

Buildings that define the urban landscape and are of architectural importance cannot be safeguarded on public green, sports fields and playgrounds, as these land uses do not require any or hardly any buildings.

Type IV: Small-sized businesses and services

This type of land use brings together a wide range of different private and public sector land uses where the public, functions and spatial orientation extends beyond the provision of the immediate vicinity. If the catchment area is no longer local but regional

and the buildings can no longer be integrated in the urban space, if they are therefore no longer “small-scale”, the land uses are allocated to the type “Large-scale business centers of regional or national importance”.

Small-scale businesses and services are predestined for a mixed function incorporating residential land use and shops and services and thus for the promotion of settlement structures of “short distances”. Like residential land use and shops and services, this type of land use also serves economical land management and to avoid traffic at locations which lie within the settlement area, have a good connection to the local public transport network and are easily accessible by bicycle. However, on account of the higher traffic incidence, these types of land use require a location where the municipal road network has the capacity to absorb additional traffic.

The presence of small-scale businesses and services in attractive urban locations can act as a trigger for the further development or start-up of innovative enterprises suitable for mixed land use.

As small-scale businesses and services do not generate heavy emissions, it is not generally a problem if they are located in the immediate vicinity of protected areas. This type of land use can similarly be established on polluted sites, for it produces hardly any activities in the outside area and generally requires a relatively high degree of sealing. Its establishment on minimally sealed sites would therefore lead to high additional sealing.

On account of the great significance that the structural quality has for the image of many businesses in this type of land use, it is suitable for safeguarding and reusing architecturally important buildings that define the urban landscape.

Type V: Emission-generating production plants and transport-intensive businesses

The land uses of this type are characterised by the fact that they cannot be integrated without conflict into small-scale settlement structures and a vicinity that is sensitive to emissions and image.

This type of land use is not suitable for small-scale mixed functions and proximity to ecologically important sites. On account of the relatively high potential for disturbance and the frequently high incidence of long-distance traffic, a location on the outskirts can be advantageous. Access to efficient public transport is not absolutely necessary; its importance depends on the number of employees to be expected. More important is as direct as possible access to the highway system if resources are to be saved and emissions reduced.

The possibility of safeguarding architecturally important buildings that define the urban landscape with this type of land use is very low; it is generally the functional requirements placed on the production buildings that are the primary focus.

The establishment of emission-generating production plants and transport-intensive businesses on sites with minimally soil will generally require considerable additional sealing; but at a location that is already contaminated this does not represent a great problem.

Type VI: Large-scale business centers of regional or national importance

This type of land use is characterised by need for large sites, little proportion of open space and large quantities of visitors.

In order to organise the large crowds of customers in a way that saves resources and reduces emissions as far as possible, large-scale business centers require an efficient traffic infrastructure. This involves both the connection to the local public transport network and to the national road network. Good accessibility by bicycle is a positive quality, but is not absolutely necessary on account of the large catchment area of this type of land use.

The constructional typologies of large-scale business centers make them solitary buildings that can only be integrated with difficulty into the urban environment. Conse-

quently, they are generally not suited for mixed land uses, especially as the incidence of traffic that they generate has negative impacts on adjacent protected and residential areas. Either very large inner city brownfield sites or locations on the settlement outskirts are therefore considered to be suitable locations for this land use.

With the requirements they place on size and functionality of the buildings, large-scale business centers are ill suited to reuse buildings of architectural importance; they will also often need further sealing of soil if sites are minimally sealed. As this type of land use is dominated by indoor activities, it is less sensitive to inherited pollution and can therefore minimise the clean-up costs for a contaminated site.

Type of land use VII: Complex mono-functional facilities with large open areas

The type of land use “complex single-function facilities with large open areas” is primarily distinguished from “Large-scale business centers of regional or national importance” by its high proportion and great importance of open areas. That is why this type of land use is assessed differently from that of Large-scale business centers with regard to the consequences for sustainable urban development. The large proportion of open areas makes this land use sensitive to emission-producing facilities in the vicinity and unsuitable for contaminated sites, but does not have an adverse impact on adjacent protected areas or residential land uses.

An efficient transport infrastructure involving the local public transport network and local road network is absolutely necessary in order to develop the public traffic in a way that saves resources and produces few emissions as far as possible. Good accessibility by bicycle is advantageous but is not absolutely necessary on account of the large catchment area of this type of land use.

The preservation or reuse of an architecturally important building fabric that defines the urban landscape is possible on account of the greater flexibility in the configuration and function of individual buildings as well as on account of the orientation on images of these land uses